

# **BIOTECHNOLOGY**

## **SYLLABI AND COURSES OF STUDY FOR B.Sc.**

### **PART-I**

### **EXAMINATIONS**

There shall be one theory paper of 100 marks and one practical paper of 50 marks each. Each theory paper shall be of three hours duration and the practical paper shall be of four hours duration. 20% of the marks shall be reserved for internal assessment in each theory paper and 50% in practical paper. Each theory paper will be set for 80marks and practical paper for 25 marks. The theory paper will have a total of 10 questions two from each unit and the candidate will be required to answer any five questions, selecting one from each unit. In case of regular students, internal assessment received from the college will be added to the marks obtained by them in the University examination and in case of private candidates, marks obtained by them in the University examination shall be increased proportionately in accordance with the Statutes/Regulations.

## **B.Sc. part – I (Biotechnology)**

### **SEMESTER-I**

### **Biochemistry and Metabolism**

#### **Unit – I**

Water and its properties; physicochemical properties of water; Dissociation and association constants, pH, buffers, pI, pKa, solutions, solubility, criteria for solubility, hydrophobicity and hydrophilicity; Dielectric constant; Thermodynamics; free energy, enthalpy, entropy and redox potential.

#### **Unit – II**

Carbohydrates, structure of mono-, di- and polysaccharides, cellulose, glycogen, starch, Glycoproteins, peptidoglycans, lipopolysaccharides; Carbohydrate metabolism- glycolysis, Fate of pyruvate under aerobic and anaerobic conditions, Entry of fructose and galactose in glycolysis, TCA cycle, Amphibolic and anaplerotic nature of TCA cycle, gluconeogenesis; Electron transport chain, oxidative phosphorylation, pentose phosphate pathway: Oxidative and non oxidative phase, glyoxylate cycle.

#### **Unit – III**

Structure of amino acids: acidic, basic and neutral amino acids, essential amino acids, Chemical reactions; Structural organization of proteins, primary, secondary: The alpha- helix, beta-pleated sheet structures, tertiary and quaternary structure of proteins and the Forces that stabilize the structure, Protein classification, fibrous and globular proteins and functions; Biosynthesis and degradation of amino acids; Reduction and assimilation of atmospheric nitrogen, nitrogen cycle.

#### **Unit – IV**

Lipids and fats, classification of lipids and fatty acids, saturated and unsaturated fatty acids, general structure and functions of major subclasses of lipids-acylglycerol, phosphoglycerides, sphingolipids, glycosphingolipids, terpenes, sterols, cholesterol and steroids; prostaglandins; biosynthesis and degradation of fatty acids.

## Unit – V

Nucleic acid, DNA :A, B & Z- DNA , RNA: Structure of m-RNA, r-RNA & t-RNA, structure and type of nucleosides and nucleotides, biologically important nucleotides and their functions. Biosynthesis and degradation of nucleic acids. Vitamins and hormones; types of vitamins and their deficiency symptoms, steroid and peptide hormones.

### Books recommended

1. Lehninger, A.L., Nelson, D.L. and Lox, M.M. (2003). Principles of Biochemistry, CBS Publishers and Distributors, New Delhi.
2. Stryer, L. (2001) Biochemistry : 5<sup>th</sup> Edition, W.H. Freeman and Company, New York.
3. Zubay, G.L., Parson. W.W. and Vance, D.E. (2006). Principles of Biochemistry: Student Study Art Notebook, Wm. C. Brown Publishers.
4. Voet, D. and Voet, J.G. (2004). Biochemistry, 3<sup>rd</sup> ed., John Wiley and Sons Inc., New York.

### Practicals

1. Preparation of physiological buffers.
2. Verification of Beer Lambert's Law for P-nitrophenol or cobalt chloride.
3. Determination of pK<sub>a</sub> value of P-nitrophenol.
4. The colorimetric estimation of inorganic phosphate.
5. Estimation of carbohydrate in given solution by anthrone method.
6. Estimation of sugar in biological samples by Dubois method.
7. Protein estimation by Lowry's/ Bradford method.
8. Analysis of urine for urea, glucose, uric acid and choride
9. Determination of acid value of a fat.
10. Determination of saponification value of a fat.

### Books recommended

1. Plummer, D.T. (1990) An Introduction of Practical Biochemistry. 3<sup>rd</sup> Ed. Tata McGraw Hill Publishers Co. Ltd., New Delhi.
2. Singh, R. and Sawhney, S.K. (2002) Introduction to Practical Biochemistry. Narosa Publications, New Delhi.

## **SEMESTER II**

### **General and Applied Microbiology**

#### **Unit – I**

History, development and scope of Microbiology, Principles and applications of microscopy (bright field, darkfield, phase contrast, fluorescence and immunofluorescence, confocal microscopy, electron microscopy). Methods in Microbiology, pure culture techniques, microbial culture media, sterilization, culture collection and maintenance of cultures, Nomenclature and Bergey's manual

#### **Unit – II**

Prokaryotic cell structure and function, Flagella and motility, Cell inclusions. Bacterial staining. Microbial growth: batch and continuous culture; Factors affecting growth; Viruses: Discovery, Classification and structure of viruses (Plant, animal and bacterial viruses), Retroviruses. Metabolic diversity among microorganisms.

#### **Unit – III**

Distribution and classification of algae (Fritsch) and fungi (Ainsworth). Reproduction and nutrition in algae and fungi. Fungi and ecosystem. Algal ecology and algal biotechnology, Morphology, motility and reproduction in protozoa.

#### **Unit – IV**

Industrial products derived from microbes, industrial enzymes, production of antibiotics, vitamins and vaccines; Single cell proteins, biofertilizers, nitrogen fixation, vermiculture, composting, herbicides and biopesticide production, Biotransformation, bioremediation of contaminated soils, biodegradation of organic pollutants and xenobiotics; bioplastics and biomining.

#### **Unit – V**

Air borne disease transmission, respiratory diseases caused by bacteria and viruses, Direct contact disease transmission, tuberculosis, sexually transmitted disease including AIDS, diseases transmitted by animals (rabies, plague), Arthropod transmitted disease (rickettsias, malaria, lyme disease), food and waterborne diseases (Cholera, Giardiasis, Typhoid), pathogenic fungi.

#### **Books recommended**

1. Stainer, R.Y., Ingraham, J.L., Wheelis, M. and Painter, P.R. (2003) General Microbiology. The Mac Millan Press Ltd. London.
2. Pelczar, M.J.J., Chan, E.C.S. and Kreig, N.R (2005) Microbiology. Tata McGraw Hill, New Delhi.
3. Prescott, L.M., Harley, J.P. and Klein, D.A. (2005) Microbiology. McGraw Hill, USA.
4. Mackie and McCartney. (1996) Medical Microbiology. Vol. 1. Microbial Infection. Churchill Livingstone.
5. Cappuccino, J.G. and Sherman, N. (1996) Microbiology – A Laboratory Manual. Addison – Wesley.

## **Practicals**

1. To study different components, use and care of the compound bright field microscope.
2. Culture characteristics of different microorganisms.
3. Different sterilization techniques. Preparation of media for cultivation of bacteria and fungi.
4. Isolation of microorganisms from soil, air and water. Colony purification.
5. Enumeration of microorganisms; total vs viable count.
6. Study morphology of molds and yeast by methylene blue staining.
7. Bacterial staining: simple staining, Negative staining and Gram's staining.
8. Biochemical activities of microorganisms.
9. Standard qualitative analysis of water.
10. Antibiotic sensitivity of microbes.
11. Microbial flora of mouth, teeth and throat.

## **Books recommended**

1. Cappuccino, J.G. and Sherman, N. (1996) Microbiology – A Laboratory Manual. Addison – Wesley.
2. Aneja K.R. (2005). Experiments in Microbiology, Plant Pathology and Biotechnology (4<sup>th</sup> edition). New Age International (P) Limited, New Delhi.

## **B.Sc. part – II (Biotechnology)**

### **SEMESTER III**

#### **Cell and Molecular Biology**

##### **Unit – I**

Cell theory, Structure of pro-and eukaryotic cells; cell wall in plants and microbes; structure and function, Plasma membrane; transport through membrane, Cell organelles; Nucleus, Mitochondria, Chloroplast and endoplasmic reticulum. Basic concept of cell signaling. Chromosome structure and function.

##### **Unit – II**

Mendelian Genetics, interaction of genes, Recombination, Bacterial genetic system; transformation, transduction and conjugation, Mutations; molecular basis, Overview of transposable elements in bacteria and plants. Structural and numerical alterations of chromosomes.

##### **Unit – III**

Central dogma, Model organisms to study Molecular biology.

Nucleic acids; DNA and RNA as a genetic material, experimental basis. DNA structure: Direct and indirect methods for analysis of DNA. Direct method; X-ray crystallography, autoradiography and electron microscopy to study DNA. Indirect methods Spectroscopy and Agarose gel electrophoresis. Factors determining structure of DNA, Hydrogen bonding in DNA, Hydrophobic interactions in DNA, base stacking, different forms of DNA: A, B, Z, Satellite DNA, Shapes of DNA; Linear and Circular DNA.

##### **Unit – IV**

General features of DNA replication and basic rules of replication. Semiconservative mode of DNA replication Experimental basis, Replication in prokaryotes, initiation, elongation and termination. Replication in eukaryotes Initiation, elongation and termination Transcription in prokaryotes, I initiation, elongation and termination. Transcription in eukaryotes initiation, elongation and termination

##### **Unit – V**

Regulation of gene expression in prokaryotes operon concept, inducible and repressible operons., Translation: structure and function of ribosomes, mRNA, tRNA, rRNA; Protein synthesis in prokaryotes initiation, elongation and termination Translation in eukaryotes initiation elongation and termination

##### **Books recommended**

1. Alberts, B. Bray, D. Lewis, J. Raff, M., Roberts K. and Watson J.D (2002). Molecular Biology of Cell (2<sup>nd</sup> edition), Garland Publishing Inc., New York.
2. Dranell, J. Lodish, H and Baltimore D (1999). Molecular Cell Biology (4<sup>th</sup> edition), WH Freeman and Co. New York, NY.
3. Das, H.K (2007.). Textbook of Biotechnology (2<sup>nd</sup> edition), Wiley Dreamteck India Pvt. Ltd, India.
4. Wilson, K. and Walker, J. (2004) Practical Biochemistry, John Wiley.

5. Singh, B. D. (1999) *Biotechnology*, Kalyani Publishers, India.
6. Karp, Gerald, and Nancy L. Pruitt. *Cell and molecular biology: concepts and experiments*. New York: John Wiley & Sons, 1996.

### **Practicals**

1. Quantification of DNA using Spectrophotometer.
2. Agarose gel electrophoresis of DNA.
3. Estimation of purity of DNA
4. Quantification of DNA using agarose gel by normalization
5. Paper Chromatography.
6. Spectrophotometry.

### **Books recommended**

1. Sambrook J, Fritsch, E.F. and Maniatis, T. (2001). *Molecular cloning. A Laboratory Manual* 3<sup>rd</sup> ed., Cold Spring Harbor Laboratory Press.
2. Dabre P.D. (1998) *Introduction to Practical Molecular Biology*, John Wiley & Sons Ltd., New York.
3. Plummer D.T. (1990) *An Introduction of Practical Biochemistry*. 3<sup>rd</sup> Ed. Tata McGraw Hill Publishers Co. Ltd., New Delhi.
4. Singh R. and Sawhney, S.K. (2002) *Introduction to Practical Biochemistry*. Narosa Publications, New Delhi.

## SEMESTER IV

### Enzymology and Bioprocess Technology

#### Unit – I

Biophysical and biochemical techniques: Principle, theory and applications of centrifugation, chromatography, types of chromatography; column, paper, TLC, ion exchange chromatography and affinity chromatography. Theory, principle and applications of Spectrophotometry (UV - VIS) and electrophoresis.

#### Unit – II

History of Enzymology, Enzyme vs chemical catalysts, general characteristics of enzymes, enzyme specificity, Nomenclature and classification of enzymes and their significance, Holoenzyme, apoenzyme, coenzymes, prosthetic group; Enzyme activity units, IU, katal, specific activity, enzyme assay methods, structure of enzyme proteins, Nature of active site, general mechanisms of enzyme action,

#### Unit – III

Enzyme kinetics, Michaelis-Menten equation,  $K_m$ ,  $V_{max}$ , equilibrium and steady state approaches for enzyme kinetics study, Lineweaver-Burk plots, enzyme inhibition reversible. Irreversible forms of inhibitions, Competitive, non-competitive, uncompetitive and mixed inhibition; Approaches for Isolation and purification of enzymes, Applications of enzymes in industries- food processing, dairy, textile, brewery, leather, detergent.

#### Unit – IV

Introduction to Bioprocess technology, Concept of Fermentation vs bioprocess, Microbial growth kinetics; types of fermentation processes: batch, continuous, fed batch; media for industrial processes, sterilization of media and air, Bioreactors, design and types of bioreactors; Agitation and aeration, impeller and sparger. Bioprocess monitoring and control, scale up, various bioprocess parameters, Effect of pH, temperature medium components on product synthesis.

#### Unit – V

Bioprocess based products-antibiotics-penicillin, streptomycin, tetracycline; ethanol, organic acids-citric acid, acetic acid, gluconic acid, butanol, single cell protein; Down stream processing, steps involved in down stream processing, separation of cells and broth, filtration, centrifugation, chromatography, solvent extraction, effluent treatment and disposal, BOD, COD.

#### Books recommended

1. Shuler, M.L. and Kargi, G. (2003). Bioprocess Engineering: Basic Concepts, Prentice Hall, Englewood Cliffs.
2. Stanbury, P.F. and Whitaker, A. (1997). Principles of Fermentation Technology, Pergamon Press, Oxford.
3. Doran, P.M. (1999). Bioprocess Engineering Principles. Academic Press, New York.
4. Tripathi, G. (1999). Enzyme Biotechnology. Technoscience Publications, Jaipur, India.

5. Palmer, T. (2001). Enzymes Biochemistry, Biotechnology, Clinical Chemistry, Horwood Publishing Chichester, England.
6. Nicholas, P, Stevans, L. Fundamental of Enzymology (1999). OxfordUniversityPress, New York.

### **Practicals**

1. Estimation of  $\alpha$ -amylase activity from saliva.
2. Effect of temperature and pH on enzyme activity.
3. Study of enzyme kinetics.
4. Enzyme purification by salt precipitation.
5. Enzyme purification by chromatography.
6. Enzyme purification by electrophoresis.
7. Isolation of yeast from fruits.
8. Study of microbial growth kinetics.
9. Determination of thermal death point and thermal death time.
10. Ethanol production by fermentation in shake flask.

### **Books recommended**

1. Plummer D.T. (1990) An Introduction of Practical Biochemistry. 3<sup>rd</sup> Ed. Tata McGraw Hill Publishers Co. Ltd., New Delhi.
2. Singh R. and Sawhney, S.K. (2002) Introduction to Practical Biochemistry. Narosa Publications, New Delhi.
3. Wilson, K. and Walker, J. (2004), Practical Biochemistry, Principles and techniques (4<sup>th</sup> edition), Cambridge University Press.



## **B.Sc. part – III (Biotechnology)**

### **SEMESTER V**

### **Plant Biotechnology and Genetic Engineering**

#### **Unit – I**

Plant tissue culture, Micropropagation, stages of propagation, advantages and applications, culture media (White's and Murashige and Skoog's); Plant growth regulators (Auxins, Cytokinins and Gibberellins) and their use in plant tissue culture; Initiation and maintenance of callus, types of callus and suspension cultures, batch cultures and continuous cultures; Somatic embryogenesis, Virus free plants, shoot tip culture, meristem isolation and culture, thermotherapy, applications and limitations; vitrification.

#### **Unit – II**

Haploid production by anther, pollen and ovule culture, embryo rescue, homozygous lines; Somatic cell hybridization; Protoplast isolation and culture, protoplast fusion and their applications, cybrids; Cryopreservation, types of cryoprotectants, freezing and storage, thawing and germplasm conservation, freeze preservation and slow growth cultures; Production of secondary metabolites.

#### **Unit – III**

Isolation of DNA and RNA from viruses, bacteria, plants and animals. Analysis and characterization of DNA by spectrophotometry and agarose gel electrophoresis. Tools in genetic engineering; Restriction enzymes: types and properties; Polymerases, DNA pol I, Klenow fragment, Reverse Transcriptase, Taq polymerase, ligases T4 and E.coli DNA ligase, kinase, poly nucleotide kinases (PNK), phosphatases, Bacterial alkaline phosphatase (BAP) and calf intestinal alkaline phosphatase (CIAP), exonucleases, DNase, RNase and Proteinases; Cloning vectors; plasmids pUC18, cosmids, Supercoils and phages Lambda; Genomic DNA library construction in prokaryotes. Isolation and purification of mRNA, First and second strand synthesis to construct cDNA, construction of cDNA library.

#### **Unit – IV**

Polymerase chain reaction, types and procedure, applications; restriction mapping, nucleic acid hybridization; DNA sequencing, Maxam and Gilbert's degradation method and Sanger's dideoxynucleotide synthetic method, DNA fingerprinting, molecular markers, RFLP, RAPD, AFLP, SSR, their applications; Introduction to Bioinformatics, Internet, search engines, biological databases, primary, secondary, nucleotide sequence database, Protein sequence databases, sequence analysis, multiple sequence alignment.

#### **Unit – V**

Gene transfer in plants using *Agrobacterium tumefaciens*, vectorless gene transfer, selectable markers, scorable markers; Major genes transferred through genetic engineering; advantages and application of Genetic engineering, production of transgenic plants with resistance against herbicides and insects; Golden Rice, Bt cotton, male sterility; ethical considerations; edible vaccines.

#### **Books recommended**

1. Hammond, J., McGarvey, P. and Yusibov, V., eds (2000), Plant Biotechnology; Springer Verlag.
2. Fu, T-J. Singh, G. and Curtis, W.R., eds (1999). Plant Cell and Tissue Culture for the Production of Food Ingredients, Kluwer Academic/ Plenum Press.
3. Gupta, P.K. (1996). Elements of Biotechnology, Rastogi and Co., Meerut, India.

4. Primrose, S.B. (1994). *Molecular Biotechnology*, 2<sup>nd</sup> edition, Blackwell Scientific Publishers.Oxford.
5. Berger, S.L and Kimmel, A.R (1996). *Methods in Enzymology, Guide to Molecular Cloning Techniques*, vol. 152, Academic Press Inc., San Diego.
6. Bhojwani S.S. and Razdan M.K. (2005) *Plant tissue culture: Theory and practice*. Elsevier Science, New Delhi.

### **Practicals**

1. Sterilization techniques for glassware/plasticware. Operational use of autoclave and laminar air flow.
2. Lab design and requirements of a standard plant tissue culture lab (It includes a visit to an established PTC lab).
3. Media preparation; making of cotton plugs, plugging and sealing of culture vessels.
4. To prepare different explants for culturing.
5. To demonstrate various steps of explant inoculation.
6. Genomic DNA isolation from plants.
7. Restriction digestion of DNA.
8. Demonstration of steps of Southern blotting.
9. Demonstration of PCR amplification.
10. Demonstration of cloning.

### **Books recommended**

1. Chawla, H.S. (1998) *Biotechnology in Crop improvement*. International Book Distribution Company.
2. Gupta, P.K. (1996) *Elements of Biotechnology*. Rastogi and Co., Meerut.
3. Henry, R.J. (1997) *Practical Applications of Plant Molecular Biology*. Chapman and Hall.
4. Razdan, M.K. (1996). *Plant Tissue Culture*, Elsevier.
5. Sambrook, J. Fritsch, E.F. and Maniatis, T. (2001). *Molecular Cloning. A Laboratory Manual* 2<sup>nd</sup> ed., ColdSpringHarbor Laboratory Press.

## **SEMESTER VI**

### **Immunology and Animal Biotechnology**

#### **Unit – I**

Introduction to the immune system – Innate and adaptive, Recognition of self and non self, Hematopoiesis and its regulation, Cells of immune system: Lymphoid cells, T cells, B cells, NK cells, Antigen Presenting Cells (dendritic cells and macrophages), Primary and Secondary lymphoid organs, Lymphatic system.

#### **Unit – II**

Antigen-Antibody interaction, Affinity and avidity, Immunoglobulins – classes, basic structure and biological activity, Complement cascade: components of complement, function of complement, different activation pathways. T-cell subsets and surface markers, Recognition of antigen by T-cells and role of MHC, Structure of T and B cell receptors.

#### **Unit – III**

Structure and organization of animal cell, Primary and established cell line cultures, mono-layer and suspension, Secondary culture, Established, transformed / continuous cell lines, commonly used cell lines. Basic techniques of cell culture in vitro; equipment and aseptic conditions, Disaggregation of tissue; cold and warm trypsinization; maintenance of cell culture; cell separation.

#### **Unit – IV**

Biology and characterization of cultured cells: Cell morphology, cell adhesion, cell proliferation, cell differentiation, energy metabolism. Measurement of growth and viability of cell in culture, Growth kinetics of cells in culture. Measurement of cytotoxicity. Scaling up of the animal cell culture. Organ and histotypic cultures. Cell transformation.

#### **Unit – V**

Immuno-diffusion and Immuno-electrophoresis, Immuno-blot, ELISA and variants of ELISA, RIA, Monoclonal antibodies, Blood products, Vaccines and hormones, DNA transfer technology, Transgenic technology, production of useful products in transgenic animals.

#### **Books recommended**

1. Roitt, I.M., Brostoff, J. and Male, D.K. (2001), Immunology, 6<sup>th</sup> Edition. Grower Medical Publishing, New York.
2. Kuby, J. (2002), Immunology. 5<sup>th</sup> Edition. W.H. Freeman and company, New York.
3. Satyanarayana, U. (2005). Biotechnology. Books and Allied (P) Ltd, (Kolkatta) India.
4. Freshney, Ian R. (2005). Culture of Animal Cells 3<sup>rd</sup> Edition. Wiley- Liss.

## **Practicals**

1. Total and differential Leucocyte count.
2. Total RBC count.
3. Haemagglutination assay.
4. Separation of serum from blood.
5. Blood grouping.
6. Double immunodiffusion test using specific antibody and antigen.
7. Rocket immunoelectrophoresis.
8. Demonstration of ELISA
9. Demonstration of sterilization techniques.
10. Preparation of tissue culture medium.
11. Preparation single cell suspension from the animal tissue.
12. Trypsinization of tissue and establishment of a monolayer and subculturing.

## **Books recommended**

1. Masters, John R.W. (2000) Animal Cell Culture – Practical approach, Oxford UniveristyPrfess, Oxford.
2. Freshney R.I. (2005) Culture of Animal Cells, 3<sup>rd</sup> Edition, Wiley – Liss.
3. Kannan, N. Laboratory Manual in General Microbiology. Palani Paramount Publications, Palani, India.
4. Talwar, G.P. and Gupta S.K. (1992) A Handbook of Practical and Clinical Immunology, CBS Publishers and Distributors, New Delhi.
5. Clynes M. Animal Cell Culture Techniques, Springer.